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A Practical Approach to Data Modeling using CCO (Common Core Ontologies)

Motivation for our Research

- We are involved in several US Army projects that require creating new logical data models and aligning several existing logical data models for ABCS (Army Battle Command Systems).
  - All the models pertain to the same domain, land combat.
  - The alignment is needed to integrate multiple ABCS.
  - The new logical models are being defined as a common model for a collection of ABCS.
- Both of the modeling efforts use an implicit domain model of land combat.
  - The implicit domain model consists of concepts defined in Army standards and doctrine.
  - Use of an implicit domain model increases the level of effort of the logical modeling activities.
- We believe a formal domain model will improve the efficiency of the modeling activities.
  - Single source for semantics
  - Interpretation of the concepts requires less domain expertise than an implicit domain model.

Land Combat Domain Model

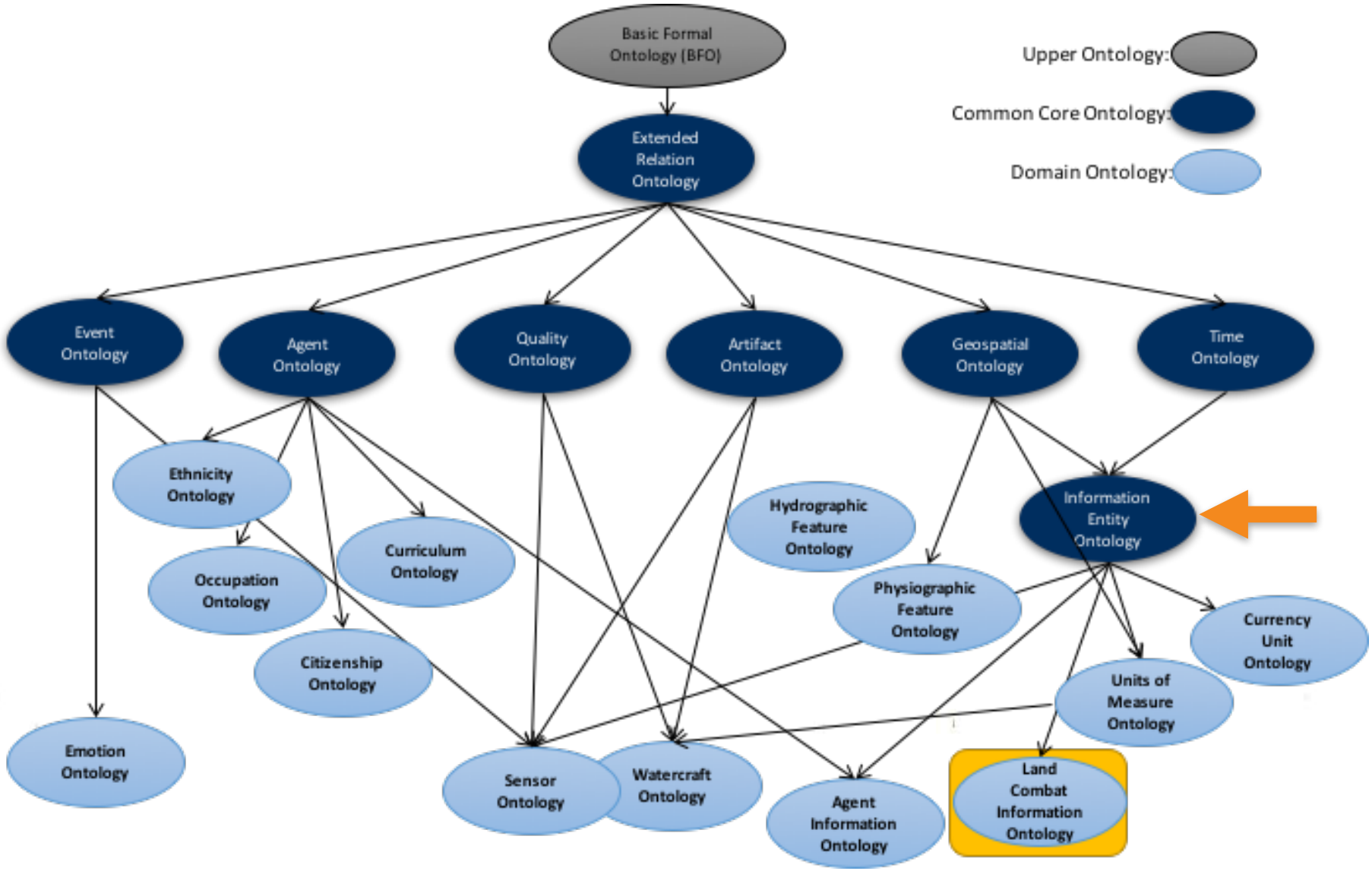
- The Land Combat domain model will be a lexicon of the informational concepts of land combat.
- Main objectives:
  - The Land Combat domain model has be translatable into logical models.
    - The Land Combat domain model has to be defined in such a way that software engineers can define mappings between the logical model and the domain model.
    - The software engineers shouldn't require any experience in ontology development to create the mappings.
  - The Land Combat domain model has to be semantically rich.

CCO as a Meta-model

- We seek to achieve semantic richness by developing the Land Combat domain model using an ontological framework.
- We use CCO as a meta-model for the domain model.
  - In other words, we develop a consistent method for adding assertions about land combat informational concepts to CCO.
- CCO is a collection of upper-level, mid-level, and lower-level ontologies that provide a framework for modeling the world.
  - Based on BFO (Basic Formal Ontology)
  - Defined in OWL
  - Developed in part by US Army CERDEC.

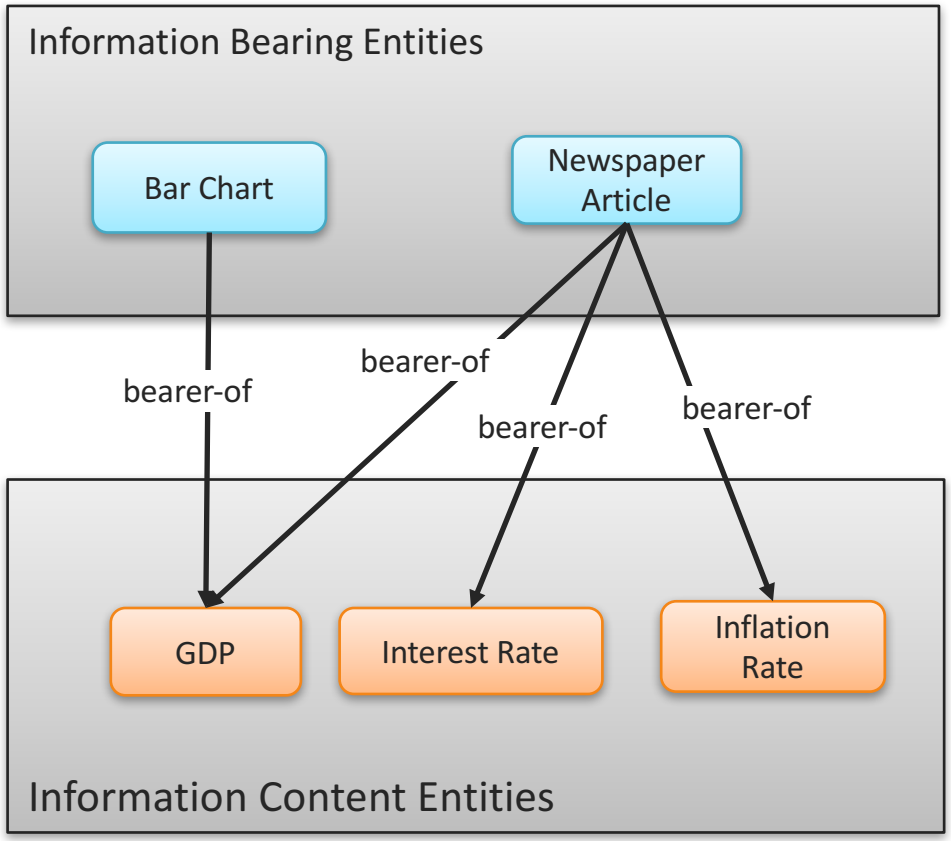
Layout of CCO

- The Land Combat Doman Model will be a Domain Ontology that extends the *Information Entity Ontology*.



Information Entity Ontology

- Informational concepts are partitioned into two hierarchies, *Information Bearing Entities* and *Information Content Entity*.
- Information Content Entity
  - A concept that represents the information about an entity.
- Information Bearing Entity
  - A concept that represents how information about an entity is organized.
  - Content Entities inhere in Bearing Entities.
  - Supports the ability to "share" information content amongst multiple containers of that information.



Modeling Methodology for the Land Combat Domain Model

- We partition information about entities into three categories.
- *Entity Artifact*
  - An informational concept that asserts information about rigid properties of an entity.
  - Example: Maximum speed of an infantry fighting vehicle
- *Entity Report*
  - An informational concept that captures observations about an entity's state at a given time.
  - Example: Position report of infantry fighting vehicle.
- *Entity Representation*
  - An informational concept describing human understandable signs and symbols which can be presented to a human actor via some sensory medium.
  - Examples: MIL-STD 2525 symbol of an infantry fighting vehicle.
- We only model Entity Artifacts and Entity Reports in CCO.

Example Information Entities

Entity: Russian Infantry Fighting Vehicle - BMP-2M

Entity Artifact

Model: BMP-2M
Troop Capacity: 7 passengers
Max Road Speed: 65km
Height: 2.45m
Width: 3.15m
Radio: R-123M transceiver
Armament: 30-mm (30 x 165) automatic gun
Fire on Move: Yes
Anti-tank Guided Missile: Kornet
Launch method: Tube-launched
Command Link: Wire
Armor: 23-33 KE
Combat Weight: 14.3 mt
Mineclearing : KMT-8 mine plow
Fording Depth: Amphibious
Cruising Range: 600km

Entity Report

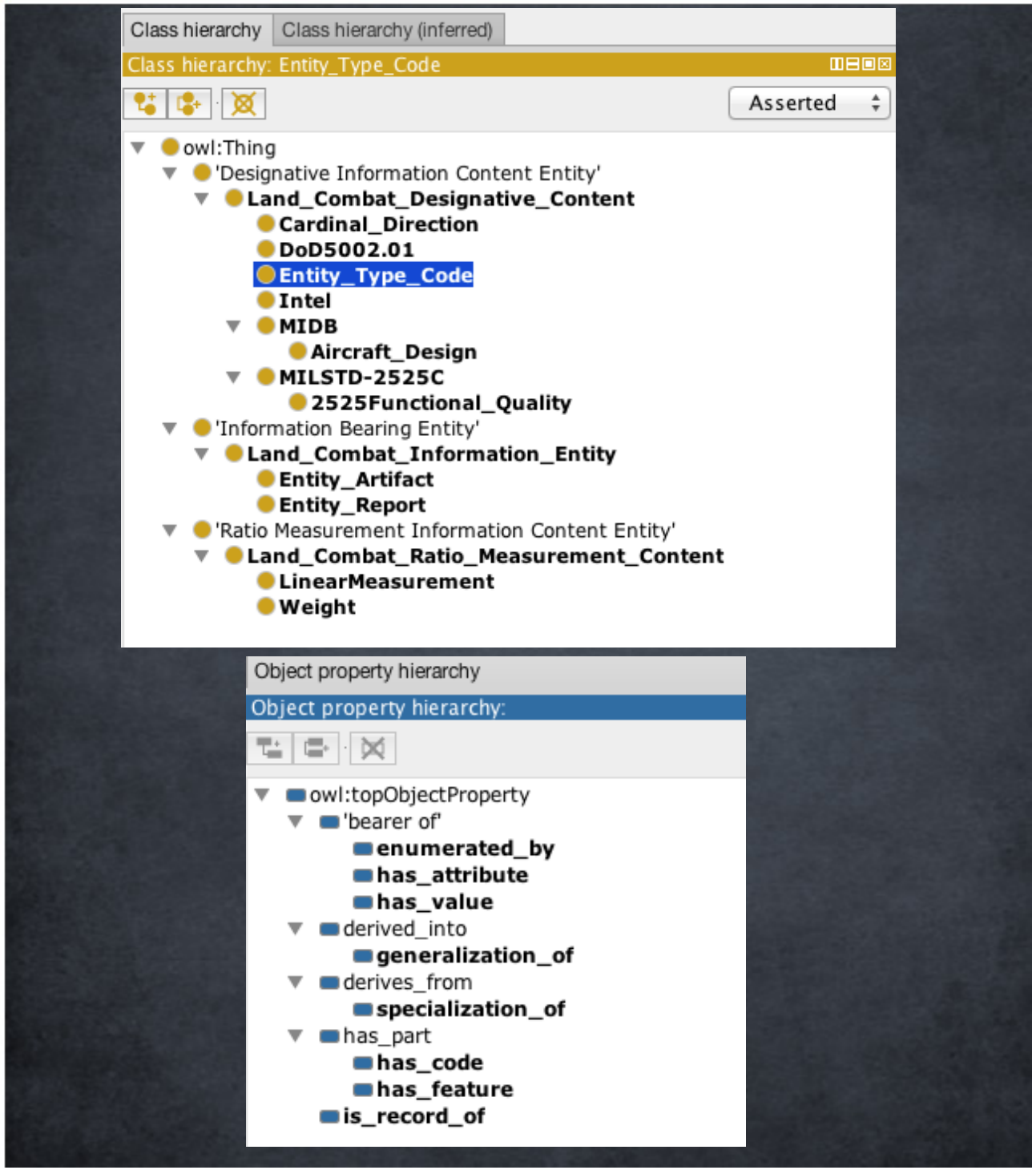
Hostile Infantry Fighting Vehicle located at 36°01.947'N 042°25.446'E. Headed north. Lightly damaged

Entity Representation

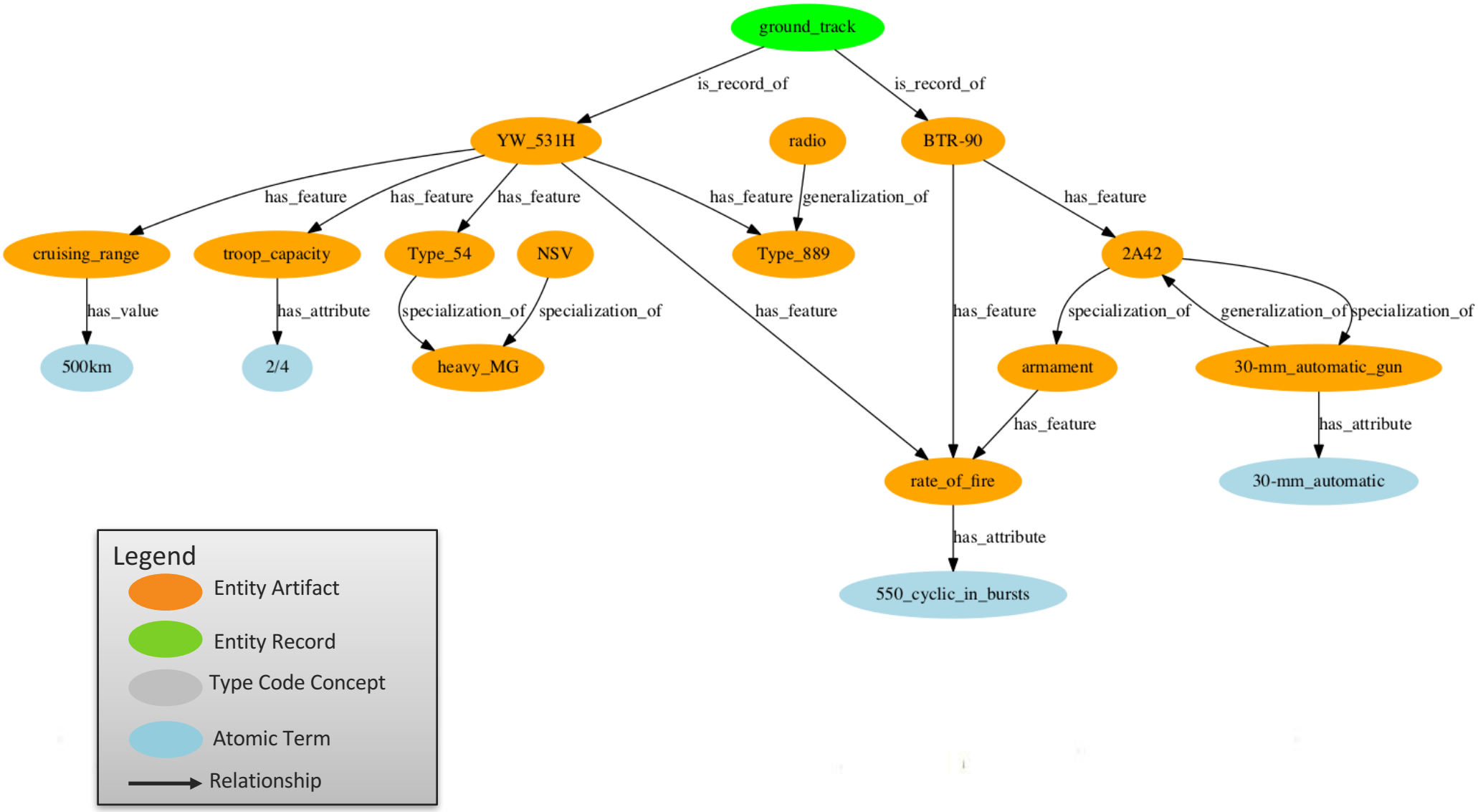
Land Combat Concepts and Properties

Modeling Land Combat as Informational Concepts

- Example land combat informational concepts
  - Tank, Infantry Fighting Vehicle, Radar
  - BTR-90, YW 531H
  - Ground track, Air track
  - caliber, rate of fire, ground pressure
  - 7.62 mm, unclassified, north, south
- Relationships
  - Subsumption
  - Whole-part
  - Affiliations
- Land combat informational concepts are defined as individuals instead of classes.
  - Information Bearing Entities: Artifacts and Reports
  - Information Content: Terms used in the definition of informational concepts.

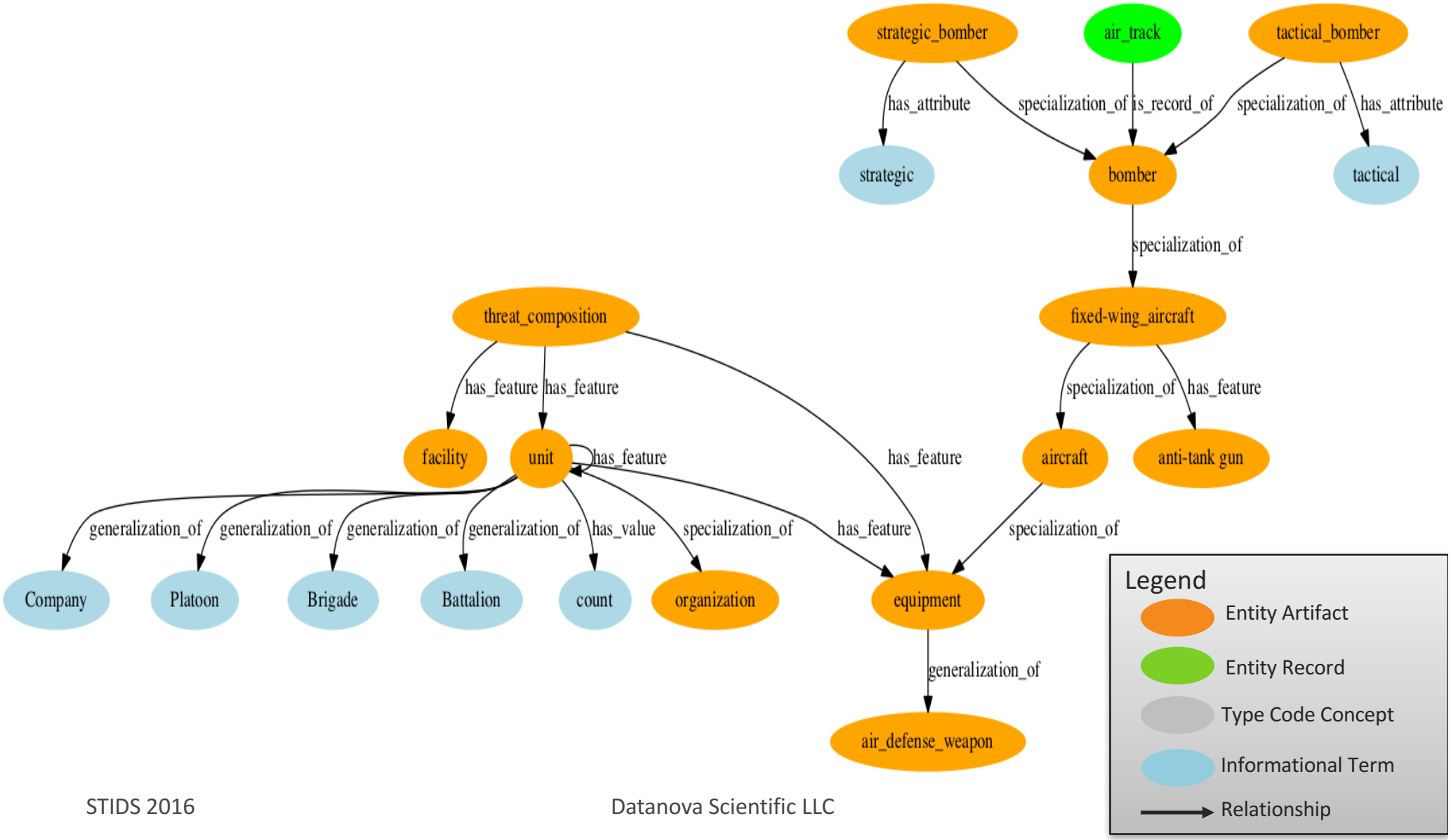


Sample of Ground Equipment Entities



Sample of Land Combat Informational Concepts and Their Relationships

- Informational concepts and their relationships are modeled as A-Box assertions.



Mapping the CCO Domain Model to ECore

- Mapping to Ecore is straightforward
  - We created the Domain Model using some of the domain modeling concepts in Ecore .
- Land Combat Information Entity becomes a class in Ecore or an enumeration class in Ecore.
  - The 'generalization of' and 'specialization of' properties determine its subclasses and parent class.
    - If *A* generalization of *B* is a triple, then the Ecore class corresponding to *A*, will be a subclass of the Ecore class corresponding to *B*.
  - The 'generalization of' and 'specialization of' properties determine enumeration literals.
    - If *A* generalization by *X* and *A* generalization by *Y* are triples, then *X* and *Y* are the enumerations of Enumeration class *A*.
    - No attributes defined for the class corresponding to *A*
- Attributes
  - 'has feature', 'has attribute' and 'has value' used to define attributes in
  - 'has code' used to define Enumeration attributes of Type Codes

Mapping the CCO Domain Model to NIEM

- NIEM Types
  - Each MC Entity individual will be a NIEM type
  - Elements of types are determine by the objects in triples
    - Objects of 'has feature' and 'has attribute' will be come composite elements
    - Objects of 'has value' will be come scalar elements
    - Use 'generalization of' and 'specialization of' for inheritance
- NIEM Code Lists
  - Objects in triples of 'has code' become Code Lists
    - Members are determined by objects of 'enumerated by'
- NIEM Association Types
  - Relation individuals become Association Types
- NIEM Metadata
  - A logical modeler determines whether an object of a 'has feature' triple should be considered Metadata.
- NIEM Augmentation and Extension
  - Augmentation point and extensions are determined from 'generalization of' and 'specialization of'.
  - The logical modeler determines whether to create an augmentation point or an extension.

Conclusion

- Creation of a domain model for land combat in progress.
- Software engineers will be able to create intuitive mappings between the domain model and logical models.
- The Land Combat domain model may be non-conformant.
  - Sacrifice conformance for intuitive mappings.